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# **Evaluation of AIRS, MODIS, and HIRS 11 micron brightness temperature difference changes from 2002 through 2006**

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# Motivation

- Ongoing AIRS instrument validation, with an interest in examining differences for cold scenes (200-250 K).
- Develop comparison methods to facilitate climate studies
  - requires analysis across/between multiple instruments/platforms
  - has to contend with instrument spectral bandpass differences, spatial footprint differences, and orbital variations
  - discussions of global warming are in the neighborhood of 100 mK absolute, with change at the 10-20 mK/yr level; supporting data sets must be of at least this quality

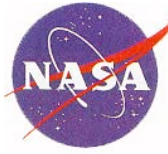


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# Introduction

- The calibration of AIRS and MODIS has been established at better than the 0.1 K level for MODIS band 31, for one day means for two test days on 20020906 and 20040218 (Tobin)
- We used tropical ocean daytime granule 20020906.176 and nighttime Antarctic granule 20020906.72 to verify this.
- Can this result be repeated with more recent data?
- What happens when we look at the radiometric validation over Antarctica?



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# Data Set

- MODIS band 31, HIRS/3 channel 8 (both 11  $\mu\text{m}$  window channels) and selected 11  $\mu\text{m}$  region AIRS channels provide a reasonable data set for developing comparison methods.
  - AIRS (Aqua)  $d\lambda/\lambda \sim 1400$  @ 11  $\mu\text{m}$ ,  $\sim 0.008$   $\mu\text{m}$  bandwidth, 13.5 km spatial resolution at nadir
  - MODIS (Aqua) Band 31, 11  $\mu\text{m}$ , 0.5  $\mu\text{m}$  bandwidth, 1 km
  - HIRS/3 (NOAA-16) Channel 8, 11  $\mu\text{m}$ , 0.5  $\mu\text{m}$  bandwidth, 19 km
  - Aqua 1:30 PM sun-synchronous orbit, NOAA-16 (L) 2:00 PM at launch (with subsequent drift in the ascending node)



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# Method

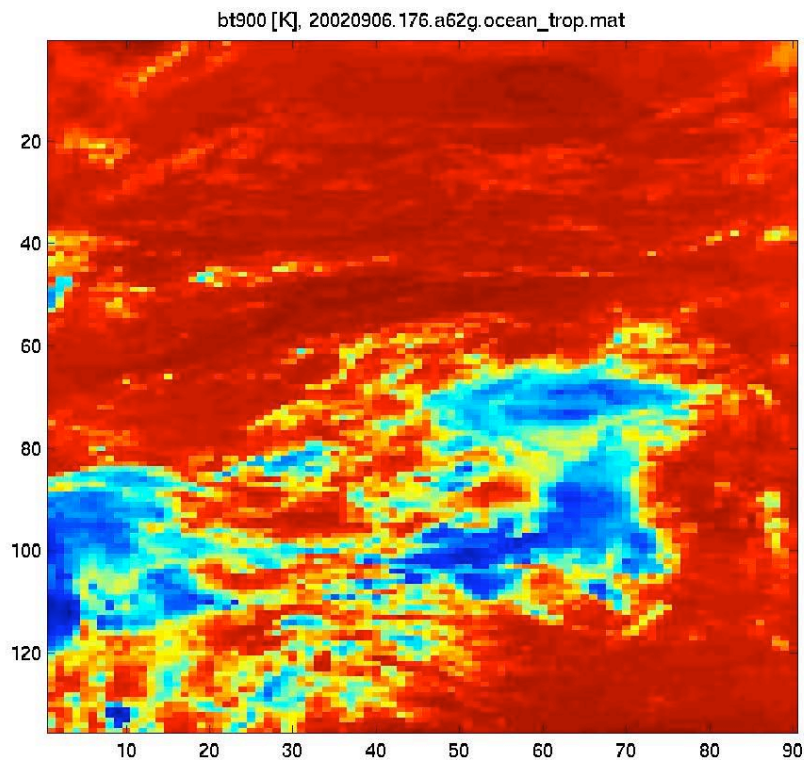
- MODIS - AIRS comparisons
  - Average MODIS band 31 (11  $\mu\text{m}$ ) radiance data to 5 km x 5 km
  - Approximate broadband 11  $\mu\text{m}$  band brightness temperatures with a linear combination of AIRS channels with frequencies 900, 912.7, 881, and 891 (trained using spectra from 48 climatologies & 6 slant paths).
  - Matchup MODIS 5 km x 5 km pixels with AIRS, using 0.075 surface degrees (~8 km) distance criterion. Results in ~9 matches per AIRS footprint.
- HIRS - AIRS comparisons
  - Use same prescription for 11  $\mu\text{m}$  broadband radiance (assumed to be the same as MODIS band 31).
  - Matchup AIRS footprints with HIRS footprints (19 km on 40x26 km centers), using 0.07 surface degree criterion. Results in 1 AIRS match per HIRS footprint.



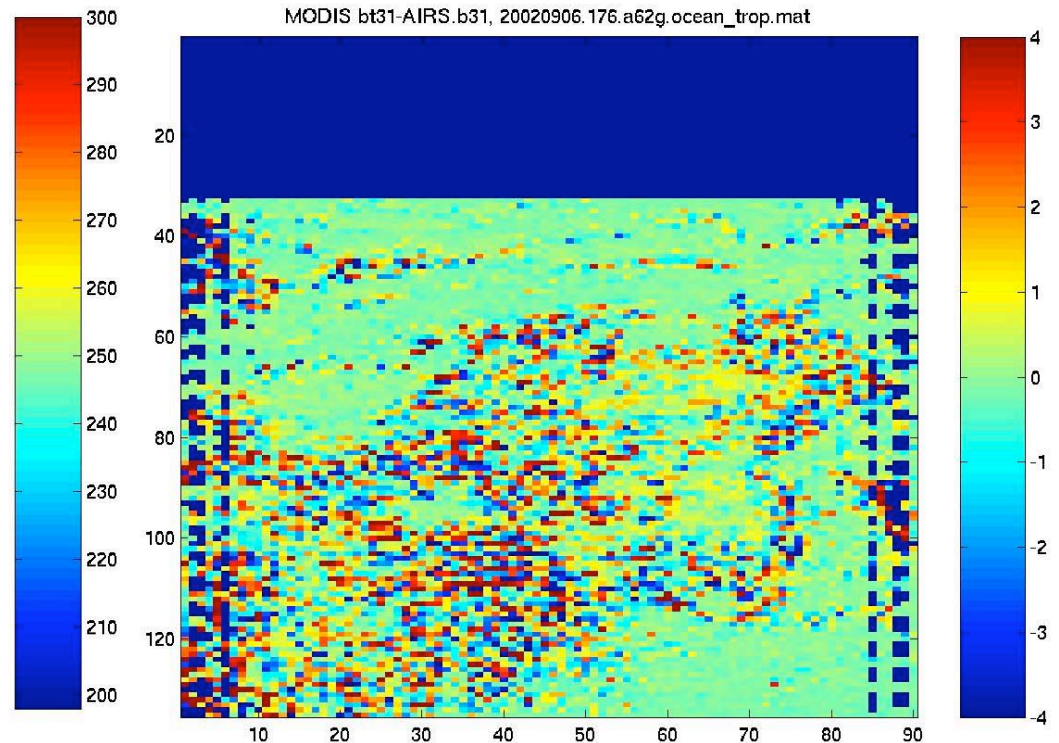
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Ocean tropical granule is cloudy, has areas of high gradient  
resulting in increased matchup uncertainties.

**AIRS Brightness Temp., 11.1  $\mu\text{m}$**



**MODIS band 31 – AIRS matchup differences.**

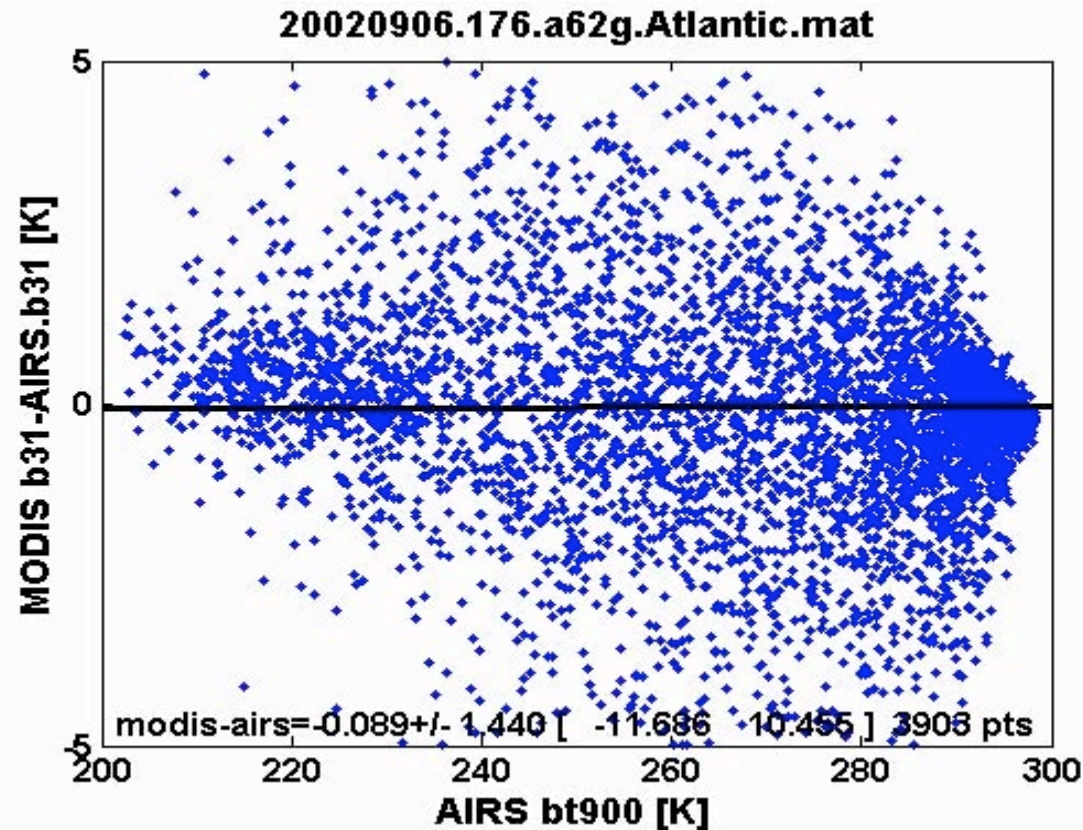






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The comparison for 20020906 tropical ocean granule  
176 looks very good down to the 200 K level



mod-s-air=-0.09 +/- 0.1.4 for 3908 points.

There is a very small bias and there is a small slope.

6296-22 7 MODIS b31 is 0.3 K warmer than AIRS at 200 K, 0.1K colder at 300 K.

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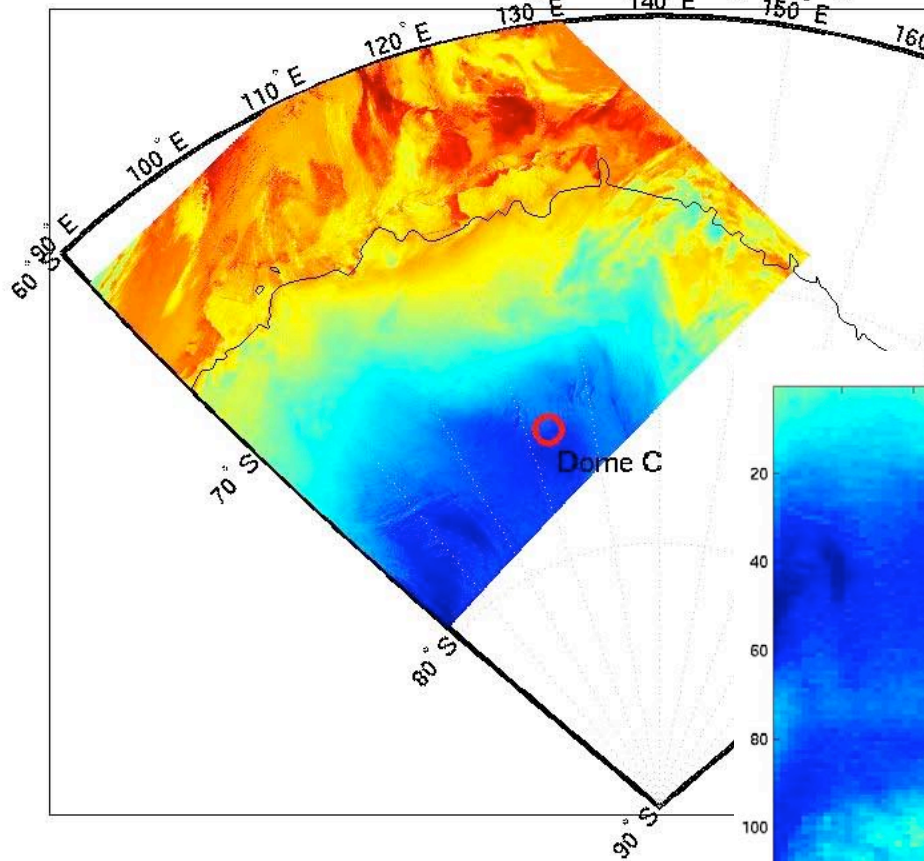


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# Differences over Antarctica significantly reduced

## MODIS granule

MOD021SS.A2002249.0715 (AIRSgran 073), band 31, BT

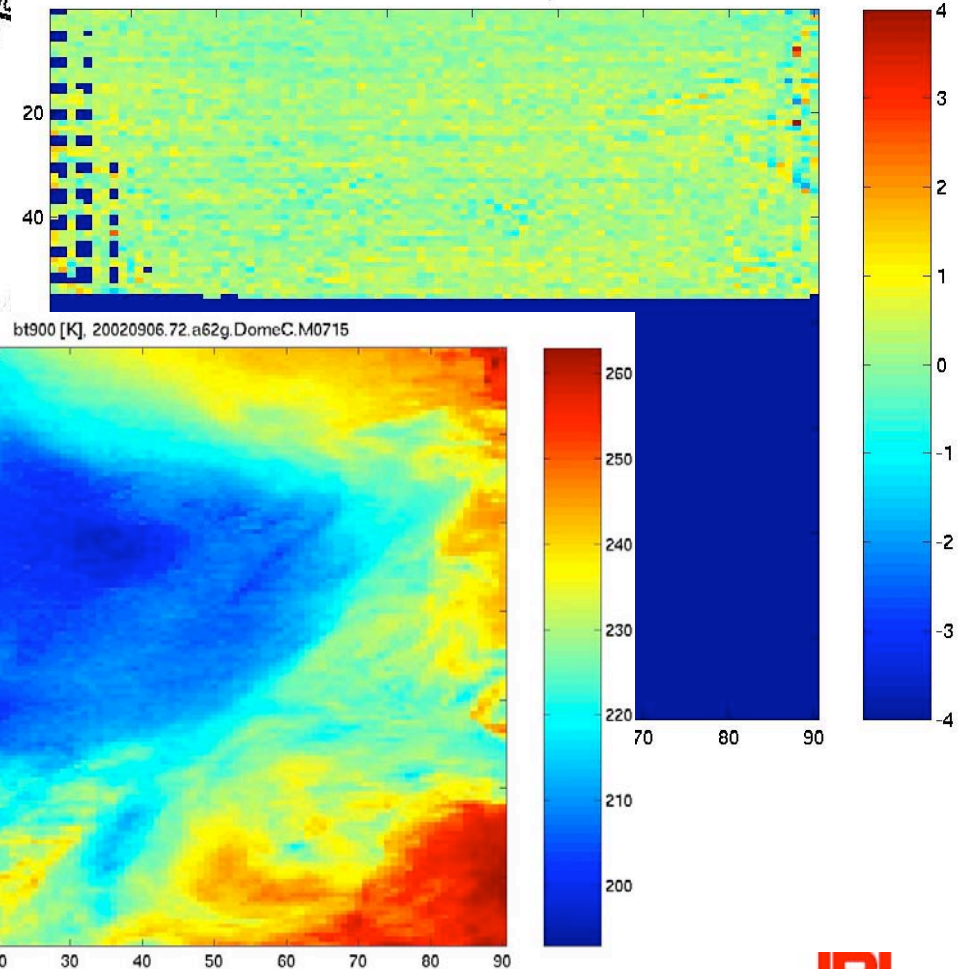


## AIRS granule

6296-22 8

## Difference image

MODIS bt31-AIRS.b31, 20020906.72.a62g.DomeC.M0715



JPL

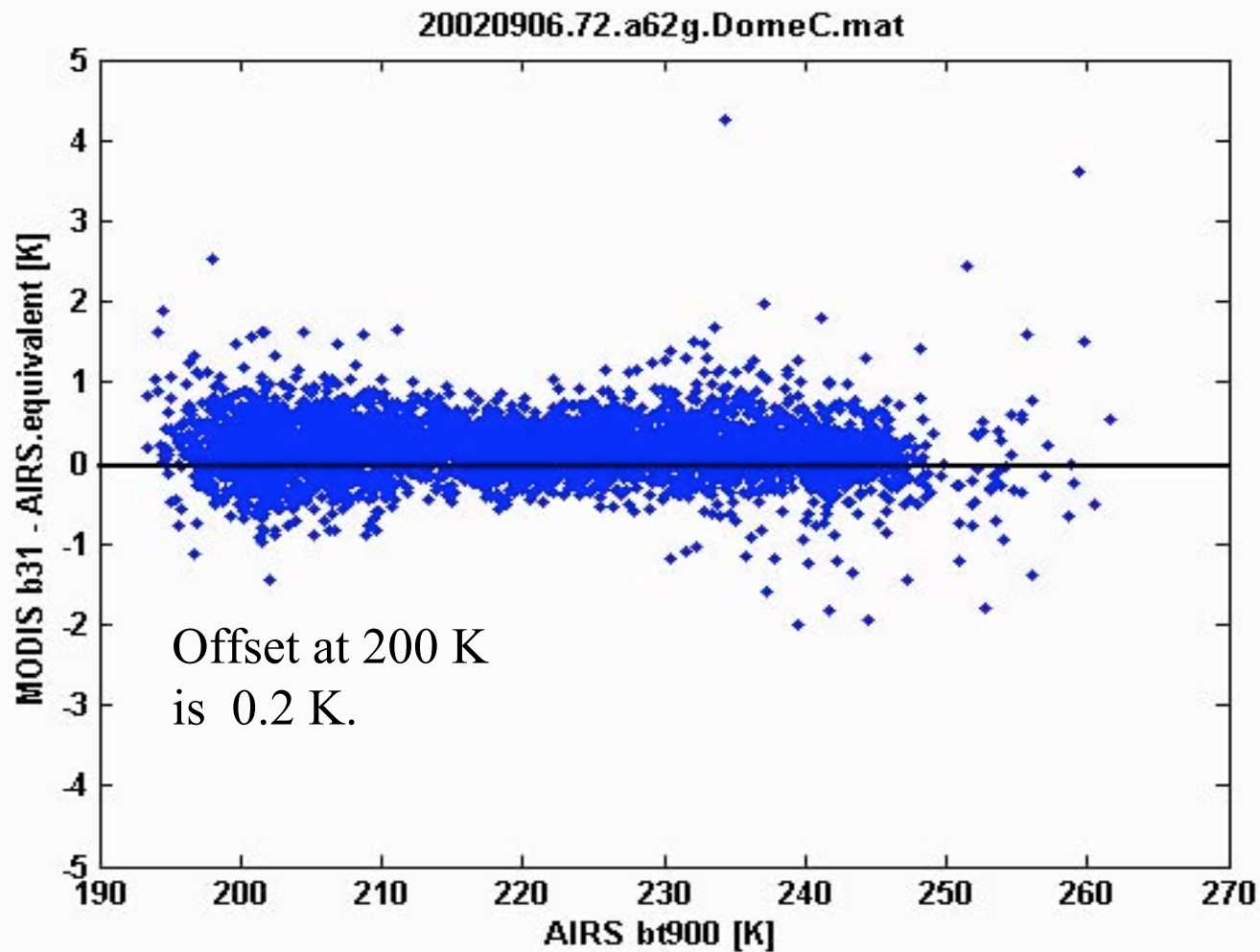




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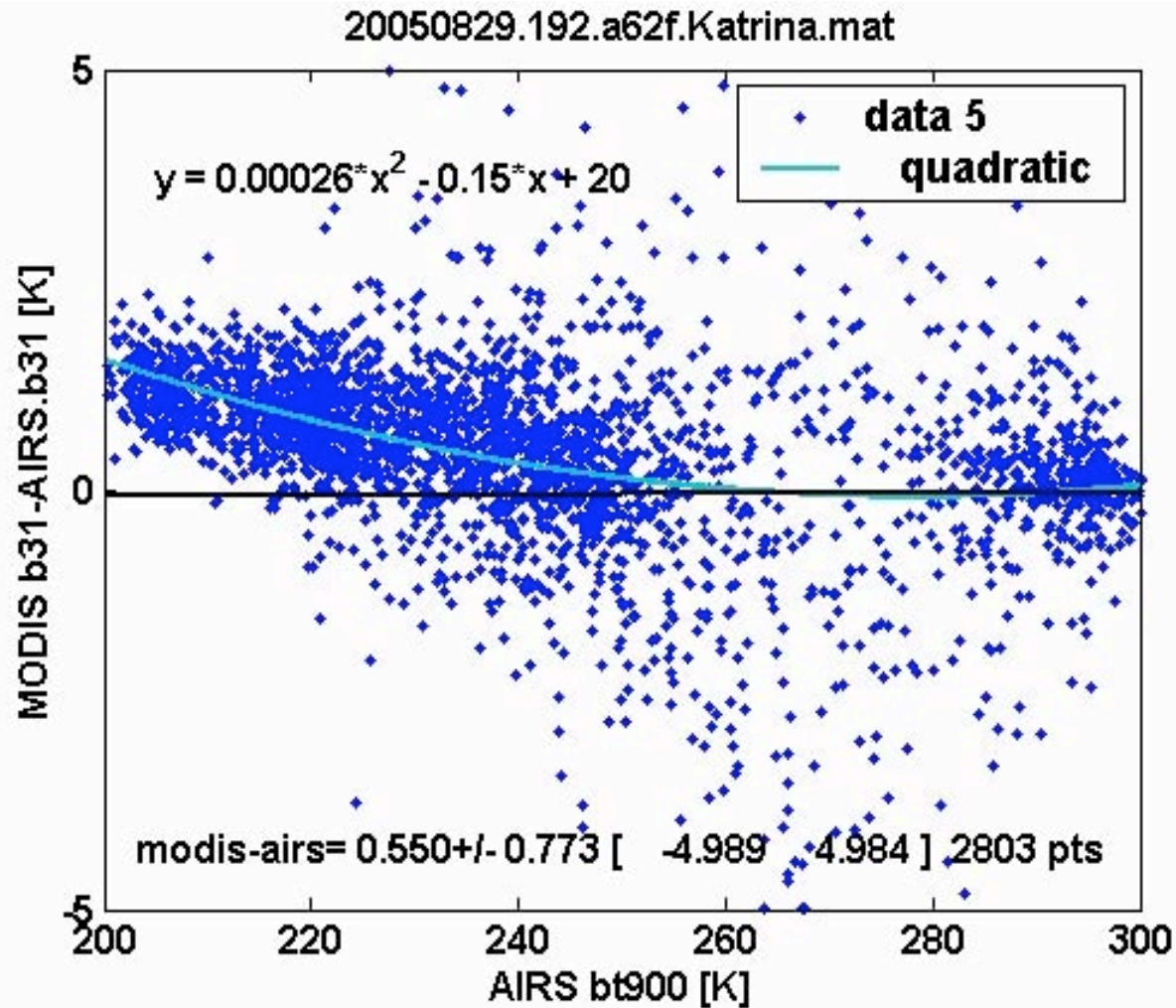
## The 20020906 granule 72 Dome C overpass comparison of MODIS and AIRS shows excellent agreement





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## 20050829, granule 192 is the New Orleans overpass with Katrina at 1:30 pm

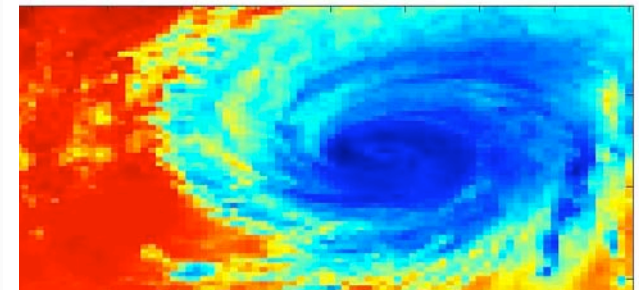


The 20050829 data look much more complicated.

There is little offset between 250 and 300K.

At 200 K, MODIS band 31 is about 1.1 K warmer than AIRS.

bt900 [K], 20050829.192.a62g.Katrina.mat





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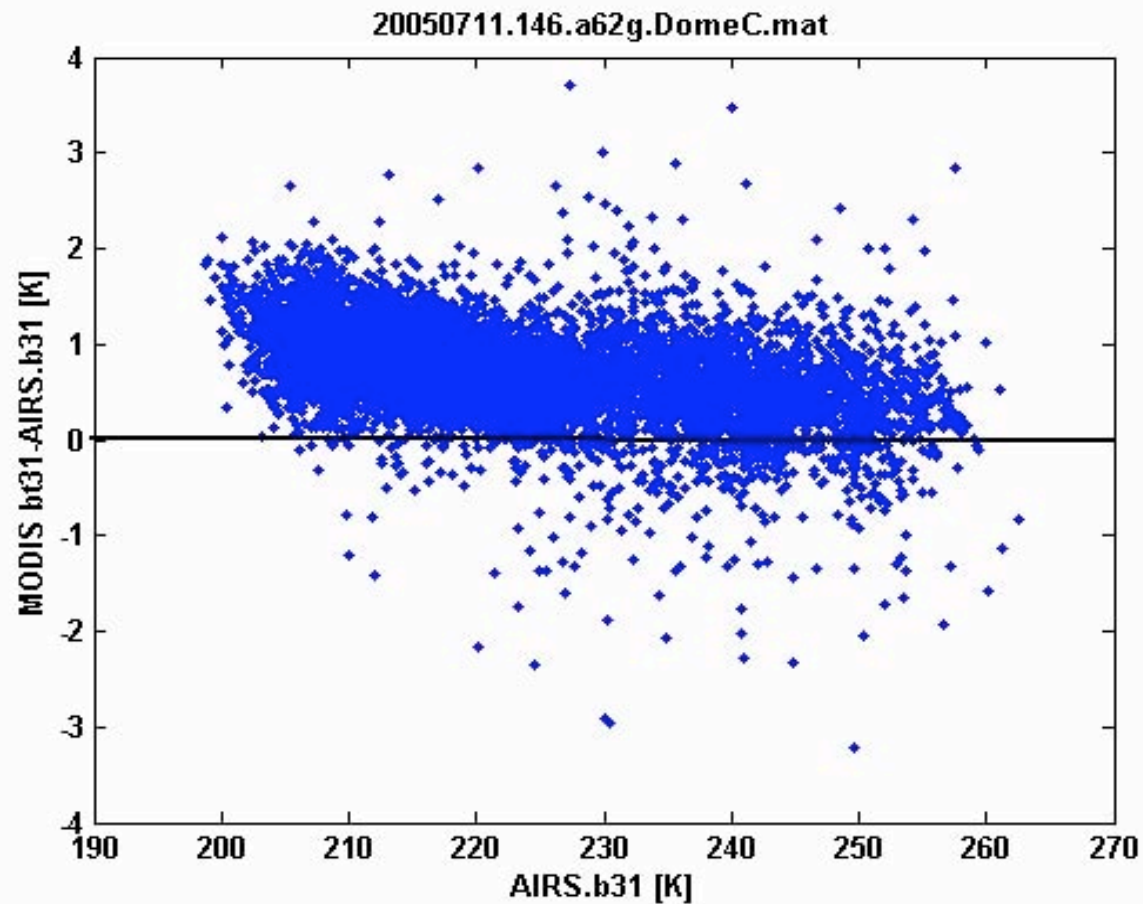
Recent (20050711) Dome C data also show a cold shift

Offset at 200 K  
is also 1.1 K.

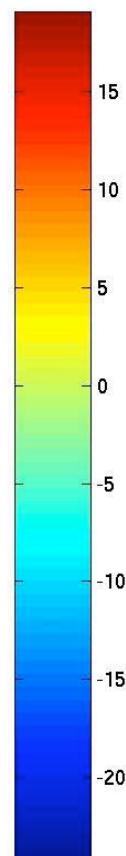
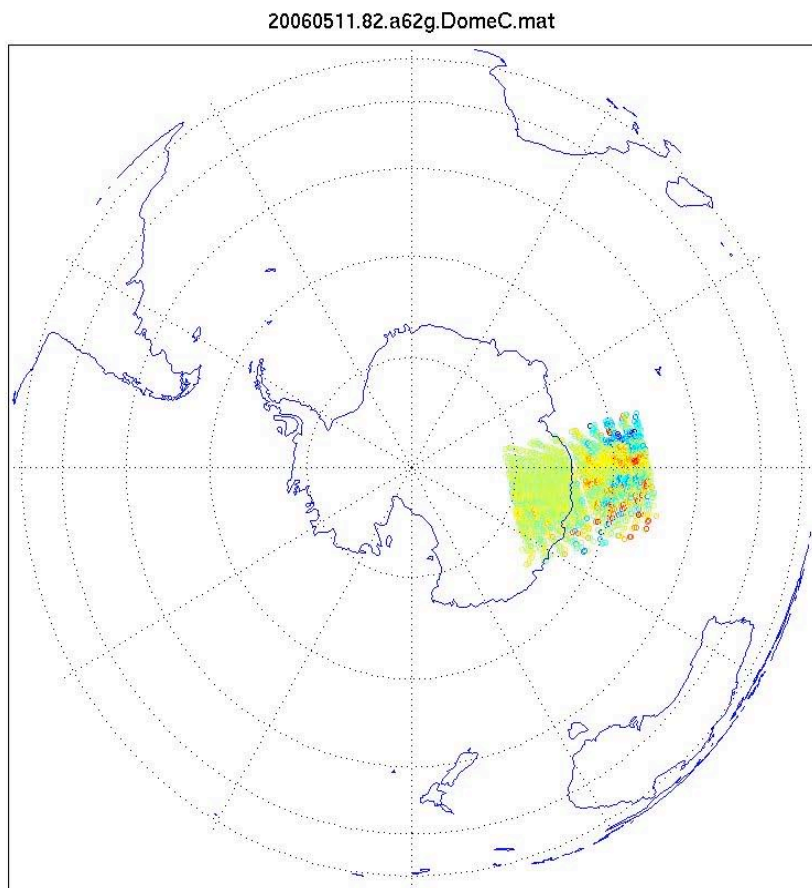
Next steps:

Increase # of  
MODIS-AIRS  
comparisons

Compare HIRS-  
AIRS



# HIRS/3 channel 8 - AIRS equivalent comparison considerations



Nearest overpass offset between 30-50 minutes, increasing with time since launch

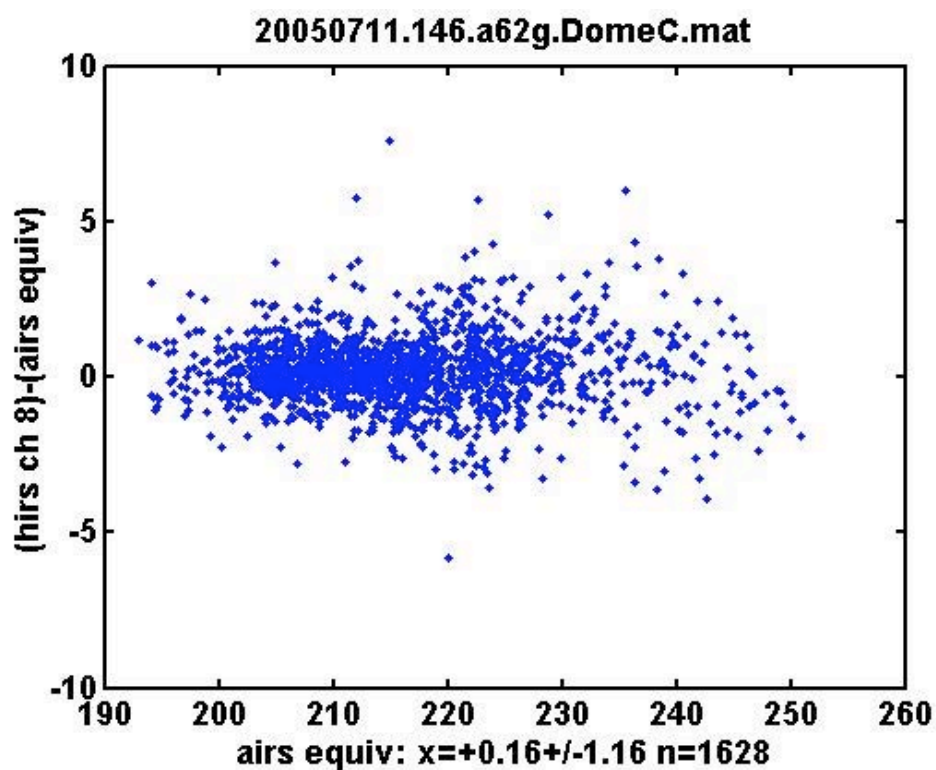
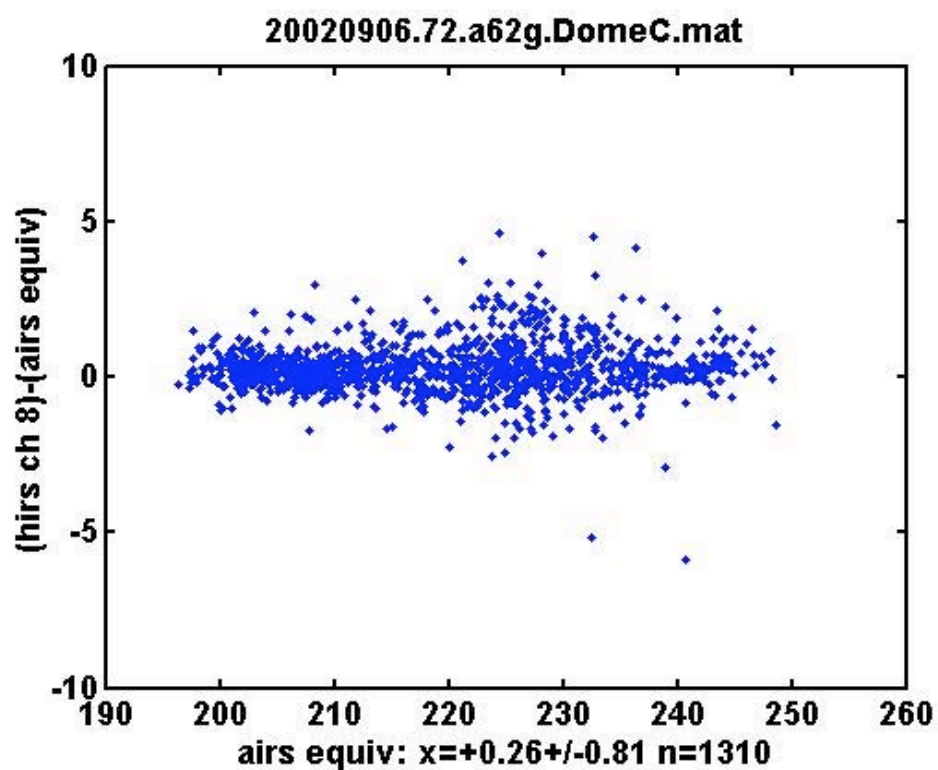
Overpass ground track angle varies:

Time:	-47m	+55	(min)
orbit < :	+14	+30	(deg)
BT diff:	.09	.23	(K)

Restricting comparisons to continent results in significant improvement



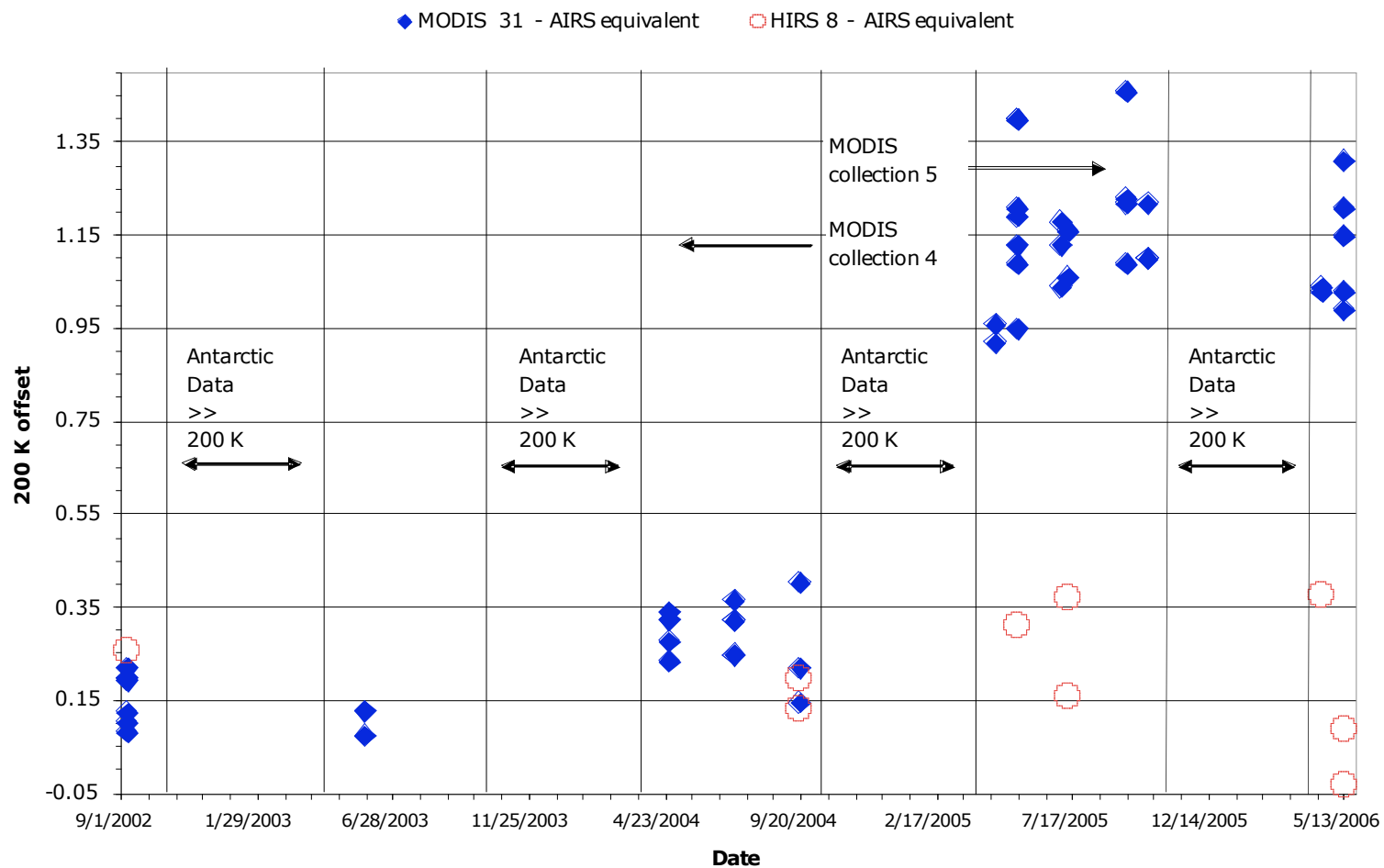
## HIRS channel 8 - AIRS equivalent, 20020906 and 20050711





# Trend of 200 K offset over Antarctica

**Trend of 200 K offset over Antarctica**





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# Discussion

- MODIS-AIRS differences agree to  $\sim 0.2 \text{ K} \pm 0.2 \text{ K}$  before level change,  $\sim 1.1 \text{ K} \pm 0.2 \text{ K}$  afterward
- HIRS-AIRS is level at  $\sim 0.2 \text{ K} \pm 0.2 \text{ K}$
- Change is coincident with change in MODIS data version
  - 200 K is a stressing calibration point - outside of required calibration range minimum of 0.3 Ltyp,  $\sim 235 \text{ K}$
  - coefficient changes ( $a_0$ ,  $a_2$ ) between versions possible source
  - pre-flight cal coeff derived from measurements down to 170 K, in-flight cal coeff based in part on 270-315 K blackbody cooldown
  - shift decreasing from lower temperatures to below 0.2 K at 260 K is indicative of a shift in the zero point (offset error)



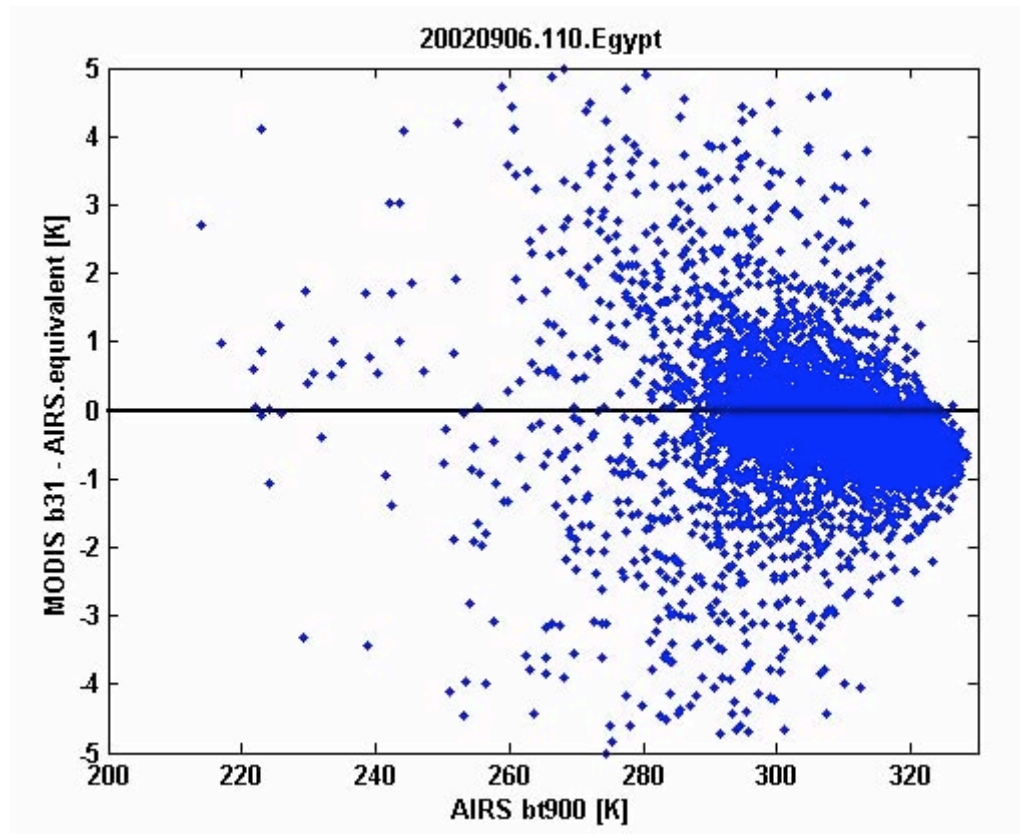
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# Summary

- Brightness temperature comparisons made over the Antarctic continent are achievable at the 200 mK level, approaching climate quality:
  - using a linear combination of the higher spectral resolution AIRS channels to make equivalent channels for broader band radiometers
  - with no constraints other than a nearness criterion for the same-platform comparison
  - for the cross-platform comparison, when the nearest overpass in time is selected (up to 50 minutes separation, in this instance)
- The method is useful as a measure of stability
  - MODIS - AIRS brightness temperature differences indicate a change of  $\sim 0.9$  K has occurred between late 04 and early 05
  - HIRS - AIRS has remained level
  - V4/V5 MODIS cal coefficients possible source of change
- MCST is currently analyzing calibration differences between V4/V5 calibration coefficient lookup tables at low temperatures
- We will try this with IASI as soon as we get data

## 20020906 Egypt granule 110 comparison shows a warm bias



In granule 176 MODIS is 0.1 K colder than AIRS at 300 K  
In granule 110 MODIS is 0.8 K colder than AIRS at 325 K